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Challenges of Advanced Training Technologies and Techniques: Beginning the Dialog

Judith A. Johnston

The increased rate and complexity of advanced technologies being developed—from unmanned vehicles to wearable computers—present a variety of training and personnel challenges. How can we streamline the training design and development process in order to keep pace with the rapid development of technology? How much knowledge of technology should be considered as a baseline for training operators of systems of systems? The desire of our military services to exploit the advantages of technology to support its members present training challenges as well. What kinds of problem solving skills can be anticipated for the use of advanced technologies? What tools and motivation should trainers provide to encourage self-initiated learning? The Training Transformation strategy of the Department of Defense (DoD) adds another set of training challenges to the mix. How can we teach multi-tasking and flexibility? How can training be designed for adequate performance and evaluation of individuals in a team environment? These questions merely scratch the surface of those currently facing technology mediated learning specialists.

Preparing individuals to understand and perform their jobs and to use technology in support of such efforts has reached a level of complexity that no longer fits neatly into an instructional design model or training requirements. As trainers and educators struggle to find immediate workable solutions, we also try to take a step back from our daily endeavors in order to under-

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Special Issue: Training

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This newsletter contains the following articles: Transitioning Perspectives to Optimize Advanced Training Designs; Future Combat Systems Manpower, Personnel, and Traning (MPT): The Challenges and Paths Forward; Calendar; Training in the 21st Century: A Human Systems Integration Perspective; The Advanced Distributed Learning (ADL) Initiative; Products

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stand what we need to do in order to address not only current but also future challenges that emerge when developing training for the effective use of advanced technologies.

This issue of *Gateway* brings together thought leaders in the domains of educational and advanced training technology who share their ideas on some of the issues and possible solutions regarding learning and training with advanced technologies. Michael and Kathleen Hannafin identify transitions we might adopt that have the potential to advance research, development, and implementation of advanced training design. John Hawley takes a careful look at personnel and training issues emerging from the Army's development of the Future Combat System (FCS). Larry Hettinger discusses the significance of training as a part of the human systems integration process, and Dexter Fletcher and Phil Dodds describe the development and implementation of Advanced Distributed Learning (ADL), as well as current performance research involving ADL.

These articles represent the tip of the iceberg regarding advanced training technologies and techniques. They provide a way to sort through some of the complexities surrounding problems and solutions and, it is hoped, a foundation for a rich and fruitful discussion among all those in our community who are touched by the need for effective training and learning with and about advanced technologies. ■

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Transitioning Perspectives to Optimize Advanced Training Designs

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Recent interest in next-generation training systems has focused much attention on emerging technologies. Still, relatively few efforts have challenged our conceptions of either training design or delivery. While legitimate reasons exist for continuing current methods, and re-hosting to new technologies, we believe that opportunities to transform our conceptions as well as methods may be lost. The risks are especially great as we see emerging interest in object economies (learning objects, knowledge objects), Web-based instruction and training, and grounded distance-based practices. These developments outpace the capacity of current design approaches to optimize advanced training designs. In this paper, we identify and describe four key transitions (T1, T2, T3, T4) with the potential to advance different training practices—research, development, and implementation. For each, we discuss roles technology might play, or is playing, as an engine for the transition.

T1: Abandon pursuit of the elusive "best way" to improve individual learning or performing.
From: Can we adapt instruction, training, and support to address individual differences?
To: Which factors contribute the most to learning and performing and how can we amplify those?

During the past forty years, significant R&D effort has been focused on Aptitude-Treatment Interaction (ATI) research, and development of associated designs, that isolate and optimize learning factors presumed to differentiate learning and performing. Unfortunately, while isolated research findings have confirmed such interactions, ATI research has proven largely fruitless in guiding practice (see Cronbach & Snow's 1970 review). Even where reliable differences in isolated factors have been found in controlled studies, they are of comparatively little influence in the face of more pervasive and powerful design factors. This is both unfortunate and frustrating to many for whom technology seemingly offered the ultimate "best way" to accommodate the myriad of individual differences evident in any population

More recently in AI research, advocates have studied and adapted instruction based upon individual learner models. While much work continues, these efforts have also proven frustrating to those interested in everyday issues related to learning and performing. Often the models are not stable, scalable or cost-effective for field implementation. For training applications, even key ATI and learner model differences are often impractical to act upon; the excessive cost, time and effort required to adapt training systems renders the findings of little practical consequence.

Given recent advances in emerging technologies and the lessons learned from past approaches, it seems appropriate to shift our focus to address some basic but critical questions: What factors contribute most to learning and performing? How can or should these factors be amplified? Of the thousands of possible influences, relatively few will exert a controlling influence; most will not account for much performance as part of an inclusive training system. Even accounting for the capabilities of emerging technologies, relatively few individual and design factors will yield large payoffs—improved effectiveness, portable and extensible training designs, and so forth. Rather, it seems prudent to harness technology's capabilities to instantiate these powerful factors into new training designs. For example, specialized features, func-

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tions, and tools designed specifically to support knowledge and skill building as well as account for task complexity and expertise development. In order to optimize advanced training systems in practice, we must shift from 'the new best way' to designs that instantiate the most effective research principles. Pursue "new best ways" in the research environment, but amplify truly powerful strategies in everyday practice.

T2: Focus on the knowledge, skill, and performance that *really* matters.
From: What knowledge and skills must people acquire, and how can we isolate and teach, train, and support them efficiently?
To: In what context do critical knowledge and skills emerge? How can we reflect situation complexity in teaching, training, and supporting?

A second transition in research and training approaches is to reflect situation complexity rather than simplify unnecessarily. Traditional designs focus on developing "efficient" training—need to know versus nice to know—training that is clearly focused and relatively simple to develop, assess, and support. Often these designs isolate "to be learned" knowledge and skills (e.g., facts, procedures) from the contexts in which individuals learn and perform. Rather than viewing a task as embedded within a piece of equipment, for example, the component knowledge and skills of the task are extracted and ordered hierarchically, prerequisite knowledge mapped, and sequences created to "impart" the requisite learning. All the trainee must do is transfer the resulting knowledge or skills to the actual problem and problem context.

In many cases, these methods have proven ineffective—and we know it. We are all too familiar with the problems associated with limited retention, meaning, and transfer, yet the approach continues to dominate training design. In truth, evidence questioning the wisdom of decontextualized training is at least as persuasive as that to continue it. There are other approaches, and technologies well-suited to support durable, transferable skills and knowledge that are better connected to the individual's own experience. Initial research findings from John Bransford and others on contextualized and situated learning show great promise for improving initial acquisition, longer-term retention and transfer to similar tasks. With the "maturity" of digital capabilities designers can more easily contextualize and situate training in authentic performance contexts.

T3: Deepen understanding.
From: How does our instruction, training, and support effect the acquisition of knowledge and skills?
To: How can our methods improve understanding about and utility of key ideas, concepts, and procedures?

A third transition focuses on promoting deeper understandings while acquiring skill. As described previously, many past approaches have focused on mastery of declarative knowledge and procedural knowledge and skill. There is a great deal of evidence that suggests these methods create "inert" knowledge—islands of information of little apparent value to existing knowledge and little prospects for transfer. While not all individuals need to develop deep understanding of all things, some knowledge and skills are more important than others and should be understood more deeply. Some have known relevance across other contexts or tasks; others are fundamental to basic problem solving related to the task or context.

Emerging technologies, and methods, offer many ways to deepen understandings. For example, systems can provide multiple demonstrations of task applications or allow end-users to manipulate and test variables to better understand their individual effects. Deep understanding can also be instantiated in team training contexts, where models and frameworks for understanding and problem solving can be represented, clarified, refined, and elaborated. Contextualization promotes knowledge and skill acquisition, rapid application, and flexibility in implementing and trouble-shooting.

T4: Embrace complexity (rather than simplification).
From: What requisite knowledge or skill needs to be taught and trained prior to higher-level learning and performing?
To: How can individuals acquire presumed requisite knowledge and skill by engaging in more complex tasks?

Traditionally, designs have focused on part-to-whole hierarchical models of learning and performing. These approaches posit a necessary

dependence between presumed prerequisite knowledge and skill and more advanced knowledge or skill. Although this approach provides a reliable design technology and a predictable methodology, it over generalizes a basic tenet of Gagne's Events of Instruction: whereas individuals may be taught effectively using hierarchical methods, they learn very differently. Little of what everyday people encounter is explicitly organized according to hierarchies and sequences. We know that it is not necessarily how people learn things. Our auto mechanics dive in and become facile through immersion; even our use of computer manuals typifies immersion in use over the orderly accumulation of facts and procedures. Few of us read or study procedure manuals anymore; for better or worse, we dive in headlong, using the manual to resolve problems as they emerge rather than as a body of prerequisite knowledge. Similarly, individuals use a range of strategies to make sense of everyday things they encounter, resolve problems, and generate new strategies.

The widespread examples of problem-based learning in medical education and case-based reasoning in the study of law are perhaps the best examples of institutionally-embraced and widely installed inductive design. While many institutions continue to use situated problems and cases to test student transfer of knowledge, an increasing percentage use them as the means to teach, and encounter, knowledge and skills in problem contexts. Participants learn both the activities and problems associated with the setting; they acquire important knowledge and skills by engaging the problem. Such designs can quickly engage trainees at appropriate levels of task complexity while providing guidance and support consistent with the work context, at varied expertise levels and across task applications.

Conclusion

It is apparent that the truly big breakthroughs will not come from the next generation technologies, but from shifts in mindsets and approaches in their use. Some transitions require going back to our future and re-focusing on things that really make a difference; others require more fundamental changes in how we think about training and technology to unleash potential not yet tapped. We have no single "best way" of our own to offer—no silver bullet to address all needs and constraints through new, and emerging, technologies. In the final analysis, it is more about changing how we view training and education than waiting for the miracle cure. ■

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Future Combat Systems Manpower, Personnel, and Training (MPT): The Challenges and Paths Forward

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Driven by technological potential, operational demands, and an evolution of military thinking, the Army is undertaking a broad-based modernization effort termed "Transformation". The newest component of Transformation is the Future Combat Systems (FCS), a light and deployable but lethal and survivable weapons concept. In essence, the Army's Transformation response involves fielding FCS-equipped combined arms battalions organized into mission-tailored, brigade-equivalent entities called Units of Action (UA). UA are further organized into tailored expeditionary organizations called Units of Employment (UE). UE will also contain FCS-compatible systems and units intended to round out their combat capability. The resulting entity is melded into an effective whole using an advanced battle command capability. Collectively, the FCS and UA are referred to as FCS-equipped UA, or FCS UA.

The FCS UA developmental effort has been termed the largest and most complex materiel, organizational, and doctrinal transformation ever attempted by the Army. In terms of complexity and scope, comparisons have been made to fielding airmobile divisions in the 1960s or the development of panzer organizations and associated Blitzkrieg doctrine by the German army during the 1920s and 1930s. In both cases, the synergy of the new whole was critical to fielding a military organization having considerably more lethality than what had gone before.

Realizing the potential inherent in the FCS UA might require a similar change in the way the Army fights and organizes for combat. It has been observed, for example, that FCS UA might resemble Special Operations Forces (SOFs) with small, non-hierarchical teams consisting of carefully selected, highly trained personnel operating in a widely dispersed area of operations but capable of producing far-reaching results—as we have recently seen in Afghanistan. The SOFs operational model is only part of the vision, however. FCS UA are also intended to engage more conventional adversaries. And the key to success in these near peer engagements is what is termed information-centric warfare—using information technology (IT) to detect and engage conventional opposing forces before they are able to close with the lighter FCS UA. Information dominance is envisioned as central to the success of FCS UA in conventional engagements. In essence, we are replacing armor tonnage and traditional punch with information superiority.

A key question at this point in the discussion is: what is necessary to make information-centric warfare a reality? The obvious direction for the FCS UA is a massive infusion of IT. Evidence from a variety of sources suggests, however, that technology alone will not be sufficient to realize anticipated gains in organizational effectiveness. Technology must be accompanied by new organizational forms and modified human resources practices.

FCS MPT Challenges and Paths Forward

New Organizational Forms

Based on the experience of the past several decades, the impact of IT on using organizations is clear. In general, IT flattens organizational structure, reduces the need for centralized operations, and results in a greater reliance on teams. For example, special operations units exhibit all of the organizational characteristics noted above, and much of the personnel-related program documentation for the FCS UA reads like a call to reorganize a large segment of the Army along special operations lines. However, special operations personnel are carefully selected, highly motivated, and rigorously

trained on a continuing basis to accomplish a mission very different from the FCS UA. The question that must be answered before pushing the SOFs argument too far is: to what extent can the SOFs model be generalized to the Army at large?

Beyond the SOFs issue, two topics directly relate to the organizational impact of IT on FCS UA. These are combined arms at lower levels and leader development.

Combined Arms at Lower Levels

Much of the FCS UA's appeal stems from its ability to operate as a combined arms force at the company level. In essence, companies become mini-battalions. While this feature is appealing, the reality is that we do not really train junior officers, or non-commissioned officers (NCOs) in combined-arms operations. Moreover, we do not have the structures in place to support combined arms operations at the company level. Companies do not have formal staffs such as exist at the battalion and brigade levels.

To make combined arms operations at lower levels a reality, the Army must revamp junior officer and NCO training to address combined arms operations and address the lack of staff capabilities at the company level. This latter issue primarily involves ensuring that adequate information processing and decision-making capabilities are present at that level.

Leader Development

FCS UA program documentation comments repeatedly that the concept's success depends in part on adaptable and flexible leaders. Adaptability and flexibility have always been essential for success in military operations. The real issue here is one of degree. Achieving the potential inherent in the FCS UA concept will require more of these characteristics than has been necessary in the past. Decentralized operations will also place a greater premium on aggressive, flexible leadership a lower levels.

The leadership literature suggests that characteristics such as flexibility and proactivity can be developed through experiential training with feedback. However, the question of whether good leaders are born or made remains. The best answer likely is that it takes a little of both—personal characteristics along with the right shaping experiences—to produce a capable leader.

Modified MPT Practices

The Army's current human resources system is an artifact of the industrial age. Aptitude and training requirements are controlled by breaking down a unit's functions into a relatively large number of job categories, many of which are not particularly highly skilled. This industrial-age job model adapted from assembly line thinking—is the basis for the Army's present occupational structure. The Army also pursues an up-or-out personnel management policy in which enlisted jobholders move up and are promoted out of hands-on technical roles. The fast track for officer promotions also favors generalists over technical specialists.

The FCS UA organizational concept in conjunction with information-centric warfare will work to overturn this system. First, there will be fewer soldiers available perform a wider spectrum of more complex job functions. Developing what has been termed multi-skilled soldiers (MSS) will thus be a necessity. The increased proliferation of complex IT hardware will also demand an increase in technical specialists with state-of-the art technical knowledge. Military Occupational Specialty (MOS) reform and the development of MSS will thus be the leading human resource challenges for the FCS UA. These changes will also produce a requirement for training reform.

Job Structure Reform

Over the past several decades, the proliferation of complex equipment has resulted in a corresponding propagation of complex MOSs that because of low personnel densities present both a personnel management and training problem. The Army's stove-piped branch structure exacerbates the situation by creating partial skill redundancies across MOSs that are similar in skill content but have different branch proponents and are thus maintained as separate jobs. Adding the FCS UA to the force will make this problem worse.

One potential solution to the proliferating number of MOS is to organize jobs around skill commonalities rather than systems or branches. Families of systems often have associated skill commonalities. And it might be possible to use these commonalities to identify core sets of skills that define jobs. One could then build upon this core set of skills to effectively enlarge a jobholder's span of competencies, thus also making it easier to develop MSS. A

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calendar

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San Antonio, TX, USA. May 4–9, 2003
74th Annual Scientific Meeting of the Aerospace Medical Association
Contact: Aerospace Medical Association, 320 South Henry Street, Alexandria, VA 22314–3579
Tel: 703/739–2240 • Fax: 703/739–9652 • URL: http://www.asma.org/

Munich, Germany. May 7–9, 2003
XVII International Annual Occupational Ergonomics and Safety Conference
URL: http://www.munich2003.com

Augusta, GA, USA. May 12–15, 2003
Department of Defense Human Factors Engineering Technical Advisory Group
Contact: Sheryl Cosing, 10822 Crippen Vale Ct., Reston, VA 20194
Tel: 703/925–9791 • Fax: 703/925–9694 • E-mail: sherylcosing@earthlink.net
URL: http://dtica.dtic.mil/hftag

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Montreal, Canada. June 16–19, 2003
SAE Digital Human Modeling for Design and Engineering Conference and Exhibition
Contact: John Miller, 755 West Big Beaver Road, Suite 1600, Troy, MI 48084
Tel: 248/273–2464 • Fax: 248/274–2494 • E-mail: dhmc@sae.org
URL: http://www.sae.org/dhmc

Denver, Colorado. June 22–25, 2003
Safety 2003 Sponsored by the American Society of Safety Engineers (ASSE)
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URL: http://www.asse.org

Johnstown, PA, USA. June 22–26, 2003
9th International Conference on User Modeling
Contact: Peter Brusilovsky, School of Information Sciences,
University of Pittsburgh, 135 North Bellefield Avenue, Pittsburgh, PA 15260
Tel: 412/624–9404 • E-mail: peterb@pitt.edu • URL: http://www2.sis.pitt.edu/~um2003/

Crete, Greece. June 22–27, 2003
HCI International 2003: 10th International Conference on Human-Computer Interaction jointly with Symposium on Human Interface (Japan) 2003 5th International Conference on Engineering Psychology and Cognitive Ergonomics and 2nd International Conference on Universal Access in Human-Computer Interaction
Contact: Maria Papadopoulou, ICS-FORTH • E-mail: administrator@hcii2003.gr
URL: http://www.hcii2003.gr

Tysons Corner, VA, USA. June 23–25, 2003
Human Systems Integration Symposium: Enhancing Human Performance in Naval & Joint Environments
Contact: American Society of Naval Engineers,
Attn: HSIS 2003, 1452 Duke Street, Alexandria, VA 22314
Tel: 703/836–6727 • Fax: 703/836–7491 • E-mail: meeting@navalengineers.org

# of events

New York, NY, USA. July 8–10, 2003
Eastern Ergonomics Conference and Exposition (EECE)
Contact: Lenore M. Kolb • Tel: 212/370–5005, ext. 23 • E-mail: lkolb@ergoexpo.com
URL: http://www.ergoexpo.com/index.asp

jul

Seoul, South Korea. August 24–29, 2003
The XVth Triennial Congress of the International Ergonomics Association
URL: http://www.iea2003.org/

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St. Louis, MI, USA. September 23–25, 2003
5th Annual Technologies for Public Safety in Critical Incident Response Conference & Exposition
Contact: Center for Technology Commercialization, Public Safety Technology Center
P.O. Box 11344, Alexandria, VA 22312
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URL: http://www.nlectc.org/conf/nij2003.html (beginning 5/01/03)

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Denver, CO, USA. October 13–17, 2003
Human Factors and Ergonomics Society 47th Annual Meeting
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Memphis, TN, USA. November 2–4, 2002
The Second International Conference on Mobile Health
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1058 Haight Street, San Francisco, CA 94117–3109
URL: http://www.intlmobilehealthassn.org

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Las Vegas, NV, USA. December 8–11, 2003
National Ergonomics Conference and Exposition (NECE)
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Training in the 21st Century: A Human Systems Integration Perspective

Larry Hettinger

Larry Hettinger is Senior Human Factors Engineer with Northrop Grumman Information Technology. He is currently the Design Agent Human Systems Integration Test and Evaluation Lead for the US Navy's DD(X) Future Surface Combatant program. He received his Ph.D. in Psychology from the Ohio State University in 1987.

Current trends in the development of complex sociotechnical systems strongly suggest that government and private sector organizations will be increasingly challenged to accomplish more with significantly diminished financial and personnel resources. Specifically, they will be called upon to develop and field systems that are more operationally effective than their predecessors, even though their design and operation will be supported with fewer traditional resources (e.g., funding, personnel, etc.). For example, the Navy's DD(X) Future Surface Combatant destroyer, is projected to operate with a dramatic reduction in crew size compared to current ships (as few as 130 crewmembers, as compared to approximately 350 on current Aegis class destroyers) with greatly increased operational capabilities. Indeed, it seems apparent that the US military's strategic paradigm is shifting away from a reliance on overwhelming force (in terms of sheer numbers of personnel and weapons platforms) toward increased reliance on superior technology, stealth, flexibility, and speed. And while critical resources underlying system development and deployment may be diminishing, performance expectations certainly are not. Clearly, the development of large-scale military systems has entered an era in which intelligent, coordinated, multidisciplinary cooperation among design disciplines will be required to produce high performance technologies.

A similar shift is occurring in other areas of the economy, those in which personnel cutbacks, budgetary pressures, and/or increased performance demands are present. The medical field is a prime example. In spite of persistent budgetary problems and personnel shortages in key areas such as nursing, there is tremendous pressure to develop and implement sociotechnical systems that improve overall system performance—particularly with respect to the reduction of medical error and the promotion of greater cost and performance efficiency. The fact that these constraints are also typically accompanied by significant timeline pressures (e.g., bringing products to market before one's competitors in the private sector; adhering to aggressive timelines for system development and deployment in the public sector) has led to significant interest in the development and application of an efficient and effective means of designing and deploying new systems.

The human-systems integration (HSI) approach provides a set of effective guidelines for accomplishing these complex and frequently conflicting objectives (see Booher, in press). The principles and methods of the HSI approach reflect an unwavering concentration on the user as the focal point of any sociotechnical system in order to achieve high levels of safe and effective system performance, and the application of a coordinated, multidisciplinary approach among the core elements of the system engineering process during all phases of acquisition from concept formulation to deployment. To date, the HSI approach has led to the development of a number of effective and safe systems in a manner whose efficiency is reflected in the life cycle cost savings, as well as in enhanced usability and effectiveness of the systems themselves. Despite several successful applications to date, the HSI model is still a work in progress with a number of important areas remaining for growth and elaboration. Nowhere is this more evident than in enhancing training to reach its full potential as a critical HSI domain.

Training and System Performance

The importance of training in supporting the effective performance of systems has long been recognized. Obviously, effective training has been, is, and will continue to be a critical element of successful systems for the foreseeable future and beyond. However, an HSI approach affords an important, new role for training within the total context of an integrated, multidisciplinary approach to systems design and deployment. It also seeks to address the apparent reality that resources for training will continue to experience significant pressure, and that the training community (like other systems engineering components) will continue to be called on to accomplish more with less.

The HSI design philosophy emphasizes three key aspects of training:

- The role training plays in supporting the effective performance of deployed systems
- The role that training considerations and expertise play throughout all phases of the design and test of systems, well before they are deployed
- The positive impact that the HSI approach can have on the training community itself, primarily by facilitating interactions with other domains whose concerns are principally with optimizing aspects of human performance.

The first point corresponds to training's traditional role—one in which a specific, fully developed system is taken as a starting point and within which the training community applies its expertise toward equipping people with the knowledge, skills, and abilities needed to interact with the system. This is the area in which training specialists have most commonly devoted their time and attention. Adding the second and third points is the challenge posed by HSI.

How can we best apply the considerable expertise contained within the training community to better support the entire system design and deployment process? How can we intelligently design systems so that training requirements will not be as onerous once they are built and deployed, thereby enabling more efficient and effective use of limited training resources? And how can training itself be improved through more thorough integration with other HSI domains and procedures?

To satisfacorily address this problem it is important to take advantage of the potential interactions between training and other elements of the HSI approach (e.g., human factors, safety and health, personnel selection, etc.), and how the products of these interactions can be used to enhance the total system development process. For instance, training and personnel selection are two areas with considerable functional overlap. Clearly it is vital for training and personnel selection specialists to efficiently interact with one another—for instance, when training informs personnel of projected personnel attributes and characteristics that will be needed to support specific systems, or when personnel informs training of a deficit of such people in the personnel assignment pool. However, it is also likely that training expertise and knowledge can inform and benefit the activities of human factors engineers, safety and health specialists, and others involved in the up-front development and testing of a new system. Similarly the expertise of these groups, in turn, can likely inform and benefit the activities of training experts.

The most compelling feature of the traditional approach to training is that research and development efforts are devoted exclusively to very specific training objectives. In other words, training researchers and practitioners work on well-defined training issues to achieve very specific training objectives. On the face of it, this may not seem like such an unreasonable proposition —indeed, it is almost a tautology. One might also argue that concentrating on very specific training objectives should produce more sharply focused and effective solutions to training problems.

However, there are at least three major problems with this approach:

- It perpetuates organizational stovepiping with its many associated problems (e.g., breakdowns in communication and coordination)
- It prevents other HSI domains from benefiting from training expertise
- It cuts off training experts from benefits that could be gained from more regular interaction with other HSI domains.

The commonly understood objectives of training, i.e., supporting the effective and efficient acquisition and retention of functional knowledge, skills, and abilities, characterizes training as a process that is unnecessarily restricted to a narrow range of activities in the life cycle of a given sociotechnical system. The HSI approach encourages the

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The Advanced Distributed Learning (ADL) Initiative

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The Department of Defense (DoD) launched the Advanced Distributed Learning (ADL) initiative in November 1997. It is the most recent and visible initiative in a long campaign to incorporate the benefits of technology-based instruction and performance aiding in routine DoD practice.

ADL is intended to accelerate large-scale development of dynamic and cost-effective learning software and to stimulate a vigorous market for these products. Under Executive Orders issued by both the last and the current administrations, ADL is to develop and demonstrate capabilities that can be adopted by all federal agencies. It is establishing a common technical framework for computer and Web-based learning that will foster the creation of reusable learning content as "instructional objects".

The goal of the ADL initiative is to ensure access to high quality education and training, tailored to individual needs, developed and delivered cost-effectively, available anytime and anywhere. This goal is viewed as something that can be achieved affordably, and thereby made feasible, only through the use of technology—specifically computer technology.

The ADL Vision

The ADL initiative is based on the view of future education, training, and performance aiding illustrated in Figure 1 (see page 14). As the figure suggests, this view, or 'vision', keys on three main components:

- A global information infrastructure that is populated by reusable instructional objects
- A server that locates and then assembles instructional objects into education, training, and/or performance aiding materials tailored to user needs
- Devices that serve as personal learning associates on which the materials are presented to users.

At present personal digital assistants (PDAs), laptops, and other personal computing capabilities suffice for ADL needs.

Sharable Instructional Objects and Learning Management Systems

To date most ADL effort has been devoted to the specification of reusable, sharable instructional objects, which are essential in achieving the ADL long-term vision. These objects must be separated from context-specific run-time constraints and proprietary systems so that they can be incorporated into other applications. They should be:

- Durable, and not require modification as versions of system software change
- Interoperable, across a wide variety of hardware, operating systems and Web browsers
- Accessible, indexed and found as needed
- Reusable, so that different development tools can modify and use them.

The server shown in Figure 1 (see page 14) will assemble material on demand and in real time. Today, much of this work is accomplished by "middleware" in the form of learning management systems (LMSs). In ADL, an LMS knows what to deliver and when, and it tracks student progress through the learning content. The key function of an LMS in the ADL context is to manage content objects so that:

- A Web-based LMS can launch content that is authored using tools from different vendors

- Web-based LMS products from different vendors can launch the same content
- Multiple Web-based LMS products and environments can access a common repository of executable content.

The Sharable Content Reference Model (SCORM)

Specification of ADL instructional content objects is being accomplished through the development of the Sharable Content Object Reference Model (SCORM). The SCORM assumes a Web-based infrastructure as a basis for its technical implementation. The ADL initiative assumes that Web-based content can be delivered using nearly any other medium (e.g., CD-ROM, stand-alone systems and/or as networked environments).

Procedures for developing content objects must be articulated, accepted, and widely used as guidelines by developers and their customers. This goal can only be achieved through collaborative development. Such collaboration requires agreement upon a common reference model. The SCORM is intended to be such a model.

The SCORM has progressed through several versions, each building on and adding to earlier ones. The latest version can be viewed at the ADL website: www.adlnet.org. It covers such issues as the ADL run-time environment and the aggregation, packaging, and sequencing of instructional objects. Future versions will accommodate capabilities such as simulation, performance support, generative intelligent tutoring, and multiplayer online games.

Businesses in the content tool development industry have as much of a stake in the production of shareable courseware objects as DoD. They are doing much of the work required to create the SCORM. A primary function of the ADL initiative is to organize, encourage, orchestrate, and document their development efforts—and to ensure that defense education and training requirements are reflected in their work.

Co-Labs

The ADL initiative has established "Co-Laboratories" in Alexandria, Virginia, Orlando, Florida, and Madison, Wisconsin, to help achieve its vision. These Co-Labs help develop and test SCORM specifications and, more generally, determine how learning technologies can be best designed to bring about specific, targeted instructional outcomes reliably within as wide a range of instructional settings as possible.

The ADL Co-Laboratories developed the SCORM conformance test software, procedures, and supporting documents. The test software may be downloaded from the ADL website.

The Case for Technology

The case for ADL instruction and interactive ADL technology may be roughly summarized as the following:

- Tutorial instruction has been shown to increase learning over classroom instruction by as much as two standard deviations, roughly increasing the performance of fiftieth percentile students to the ninety-eighth percentile. Tutorial instruction may be an imperative for efficient learning, but it has been unaffordable because it requires one instructor for each student.
- ADL instruction and technology can, in many cases, make this instructional imperative affordable. Under any appreciable student load, it is less expensive to provide instruction with technology than to hire a sufficient number of tutors.
- Instruction using ADL technology has been found to be more effective than current instructional approaches in many settings across many subject matters. Analyses of the more than two-hundred and fifty empirical evaluations that have compared the use of ADL technologies with classroom instruction have shown improvements ranging from an average of 0.40 up to 1.05 standard deviations.
- ADL instruction is generally less costly than current instructional approaches, especially when many students or expensive devices are involved. Reductions in operating and support costs average about sixty-three percent. Savings in the time needed to achieve given instructional objectives average about thirty percent.
- ADL instruction is often the most cost-effective alternative for distributing instruction and for sustaining and enhancing the capabilities and readiness of military personnel after they are assigned to duty stations.
- ADL instruction will become increasingly affordable and instructionally effective with the development and use of standardized instructional objects. Early results indicate savings of about fifty percent.

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Overall, a rule of "thirds" emerges from assessments of instruction using ADL technologies. Their use reduces the cost of instruction by about one-third, and it either reduces time of instruction by about one-third or it increases the skills and knowledge acquired by about one-third.

The Server and Intelligent Tutoring Systems

An important technical challenge for the ADL initiative is construction of the Server shown in the middle of Figure 1. Help is on the way in the form of Intelligent Tutoring Systems (ITS).

"Intelligent" in the context of intelligent tutoring systems refers to the specific functionalities that are the goals of ITS development. They require ITS to generate instruction in real time and on demand as required by individual learners.

The ADL initiative and the development of ITS, then, have a number of key goals in common:

- Both are generative in that they envision the development of presentations on demand, in real time
- Both are intended to tailor content, sequence, level of difficulty, level of abstraction, style, etc. to users intentions, backgrounds, and needs
- Both can be used equally well to aid learning or decision making
- Both are intended to accommodate mixed initiative dialogue in which either the technology or the user can initiate or respond to inquiries in natural language
- Both will benefit greatly from a supply of sharable instructional objects readily available for the generation of instructional (or decision aiding) presentations.

Web Development and ADL

The World Wide Web has reset the development agenda for technology-based instruction development. It has established an ever-improving communications and delivery platform for accessing knowledge. Much of the development work once needed to adapt to the latest technology platform has been eliminated. The Web has become the universal delivery platform. It has freed learning system developers to focus on next-generation learning architectures. The emerging semantic Web, which along with its ontology will allow us to export any knowledge representation system onto the Web and link it to any other, will only strengthen this link—substantially.

Conclusion

The ADL initiative is intended to take advantage of the rapid growth of electronic commerce and the World Wide Web, and apply it to the needs of the learning community and life-long learners. It will help provide the learning resources that the DoD needs to ensure the operational effectiveness of its forces. It will help provide similar resources to all federal agencies, which also depend on human performance and competence. Cooperative development among all economic sectors—government, private industry, and academic—is needed and is being used to achieve the goals of the ADL initiative. ■

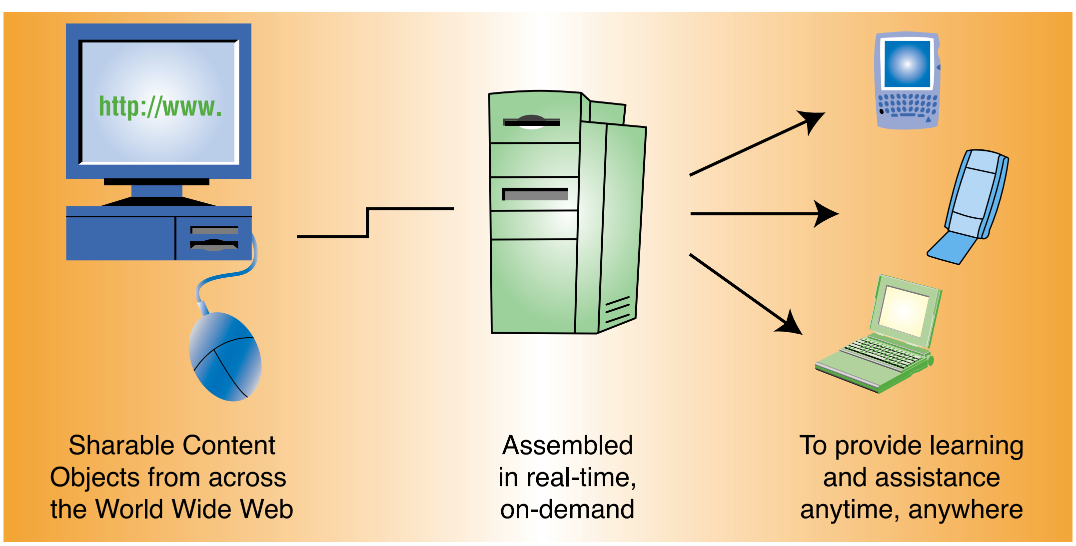

Figure 1. An Advanced Distributed Learning Future.

…continued from Hawley article on page 7

job enlargement approach to multi-skilling might also make distance learning and enhanced job performance aiding more productive.

Multi-Skilled Soldiers

With FCS UA, a situation is emerging in which there will be fewer soldiers available to perform a broader and more complex spectrum of tasks. These opposing trends will necessitate the development of what have been termed MSS. We must not forget, however, that the human performance equation is simple: performance is a function of aptitude and training. One cannot ask soldiers to perform a broader range of more complex tasks while at the same time expecting no increase in training, aptitude, or experience. Moreover, aptitudes in the Army's recruit population have remained relatively constant for the past fifty years and are not expected to change in the foreseeable future.

There is no simple solution to the requirement for MSS. However, one potential path forward is to trade experience for aptitude by retaining expertise at lower levels in the organization, which will require the Army to modify its current up-or-out personnel management practices and not penalize soldiers for remaining technical specialists. Potential means of retaining expertise in line organizations might include an increased use of warrant officers or technical enlisted ranks. It will be necessary to promote some soldiers on the basis of skill attainments and seniority rather than formal position.

Training Reform

Training loads are driven by trainee numbers along with doctrinal and equipment complexity. Fielding FCS UA will mean more complex doctrine and materiel. Information-centric warfare appears much more sensitive to competent soldier performance than was the case with previous generations of military doctrine and materiel. This means the Army's formal training burden will increase with FCS UA.

One way to lessen the FCS UA's impact on the Army's training base is to make training more efficient. A potential path forward in this respect is to rethink the traditional relationship between institutional and unit training. It may be necessary, for example, to train basic skills in a school environment and then do assignment-specific training within units. One point is clear, however: the training paradigm that grew up around the industrial-age Army must change to one appropriate for the needs of information-centric warfare. ■

…continued from Hettinger article page 11
incorporation of training expertise and requirements at all stages of the system development process.

Figure 1 provides a conceptual illustration of the role of training in the systems development process as implied by the HIS approach to training. The figure illustrates the concept of training, along with the other HSI domains, working in close cooperation with one another throughout all major phases of system development.

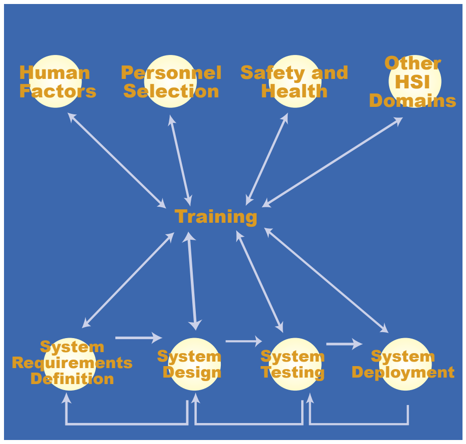

Figure 1.
Schematic representation of the system development process featuring an expanded role for training (Hettinger, in press).

The satisfactory application of HSI principles to complex system design not only requires that appropriate and up-to-date knowledge about designing and implementing training programs be employed, but also that training considerations be factored into the discussions of system design at all stages, and in conjunction with all of the other HSI disciplines.

Conclusions

Perhaps the most significant obstacle preventing the implementation of the approach described in this article is the nature of organizational culture underlying large system design efforts. In order for an HSI approach to systems development to be adopted, a dramatic change in culture is needed. Indeed, the change required is so dramatic that it might justifiably be considered the system development equivalent of a scientific paradigm shift in the Kuhnian sense (Kuhn, 1962). Simply put, a shift is needed away from the currently dominant engineering-centered paradigm of systems development toward a human-centered paradigm.

The engineering-centered paradigm places overriding emphasis on the definition, design, fabrication, integration, test and deployment of the mechanical and computer-based aspects of advanced systems. No rational individual would suggest that these elements of system design are somehow unimportant, or that they should be relegated to a subservient role within the system design process. However, what is needed is a design model that approaches all engineering questions (indeed all system design questions of any sort) in terms of their impact on users, both as individuals and as teams. The purpose of this article has been to illustrate the means by which one element of the HSI approach, the training element, can meaningfully contribute to the larger goals of safe and effective complex systems design.

Acknowledgment

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